

BREEDING BIOLOGY AND NATURAL HISTORY OF THE BAHAMA SWALLOW

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ABSTRACT.—The Bahama Swallow (*Tachycineta cyaneoviridis*) is an obligate secondary cavity-nester endemic to the pine forests of four islands in the northern Bahamas. The near-threatened status of this poorly known species stems from the limited extent of pine forest breeding habitat, a history of logging in that habitat, and potential competition from exotic secondary cavity-nesters. Natural nest sites of Bahama Swallows on Grand Bahama generally were abandoned woodpecker cavities and nests in all types of cavities were built from pine needles, *Casuarina* spp. twigs, and grass. Mean clutch size was 3.0 and the pure white eggs were slightly larger than those of Tree Swallows (*T. bicolor*). Both the mean incubation and nestling periods, 15.8 days and 22.7 days, respectively, were longer than those of Tree Swallows. Hatching success and nestling success were 87% and 81%, respectively, giving an overall success rate of 70%. One case of double-brooding was documented, and two other likely cases were noted. Weekly surveys of adults in pine forest habitat on Grand Bahama during breeding gave a linear density of 0.18–0.25 pairs-km⁻¹. The result from a single survey on Andros (0.21 pairs-km⁻¹) corresponds to survey results on Grand Bahama in the same period and very roughly agrees with the outcome of a 1988 survey. Received 13 October 1995, accepted 18 February 1996.

The Bahama Swallow (*Tachycineta cyaneoviridis*), currently listed as near-threatened (Collar et al. 1992), is a poorly known endemic of the islands of Andros, Abaco, New Providence, and Grand Bahama in the northern Bahamas (American Ornithologists' Union 1983). Like other members of the *Tachycineta* genus, the species is an obligate secondary cavity-nester (Turner and Rose 1989). Bahama Swallows nest mainly in cavities in Caribbean pine trees (*Pinus caribaea*), and their breeding season distribution corresponds to the distribution of the pine forest (Smith and Smith 1989). Smith and Smith (1989) summarized most known information about the species from previously published anecdotes and their own limited observations, yet much remains unknown. Neither its nest nor eggs has been reliably described (Smith and Smith 1989), contrary to reports otherwise (Turner and Rose 1989). The need for more information about the Bahama Swallow is obvious if we are to understand the conservation needs of this near-threatened species.

Conservation concerns for the Bahama Swallow stem from the limited extent of their pine forest habitat and a history of logging in that habitat. A recent silviculture inventory gave the total area of pine forest in the Bahamas as 2042 km² (Allan 1986) and, though the total extent of forest

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apparently has not changed due to logging (Henry 1974), most of it is second growth (Swenson 1986). No logging in the Bahamas has occurred since the early 1970s (Henry 1974), but history shows how quickly this limited habitat can be altered. Over 70% of the forest on Grand Bahama was harvested in just three years during the peak of logging there in the 1950s (Henry 1974). This comprised nearly 30% of all pine forest in the Bahamas. Given the limited nature of breeding habitat and the extent of loss possible through logging, concern about the conservation of the Bahama Swallow is appropriate. Conservation problems caused by loss of habitat could be exacerbated by competition for nest sites with exotic secondary cavity-nesters, House Sparrows (*Passer domesticus*) and European Starlings (*Sturnus vulgaris*), which are also present in the Bahamas.

As the first step in addressing the conservation concerns associated with the Bahama Swallow, I report here the findings of recent research on their natural history and breeding biology. I use the Tree Swallow (*T. bicolor*), a temperate congener, as the basis for comparing various aspects of Bahama Swallow breeding biology since none of the tropical congeners of the Bahama Swallow (e.g., Mangrove Swallow *T. albilinea*) is as well-known. I also describe results of surveys that expand upon a pilot survey in 1988 (Smith and Smith 1989) and which provide baseline information for monitoring the population size of the Bahama Swallow.

STUDY AREA AND METHODS

I studied breeding Bahama Swallows on Grand Bahama (26°40'N, 78°30'W) in the Bahamas from mid-March through June 1995. I found nests in natural sites throughout the forested part of the island between Freeport and McClean's Town, about 75 km east of Freeport. Most nests in artificial sites were located at an abandoned U.S. Air Force missile tracking base (hereafter "Missile Base") near Freetown (26°37'N, 78°21'W) about 35 km east of Freeport. All nests were either in or adjacent to tracts of secondary pine forest which make up most of the interior of Grand Bahama east of Freeport. Most nests in natural sites were found by observing swallows loitering on dead pine trees ("snags"). Nests at the Missile Base were found by systematic searches of artificial cavities and by observing swallows. The presence of a nest in an inaccessible nest site (i.e., most snags) was inferred by seeing swallows entering a cavity with nest material or by observing birds entering a cavity on several different occasions.

Most nests in natural sites were observed from the ground once every two or three days, but some were observed only once or twice in two weeks during the first few weeks of the breeding season. Observations generally lasted only long enough to confirm that a nest was still active. Activity was determined to have ceased at a nest when either two 0.5 h observations on consecutive days showed no activity or when a single 1 h observation revealed no activity. However, I often made extra observations to confirm lack of activity. If activity at a nest ceased without my having observed about three weeks of frequent nest visits (which I assumed to be feeding visits), the nest then was assumed to have failed unless some other clue (e.g., previous sightings of nestlings looking out of the hole) indicated probable fledg-

ing. Dates of either fledging or failure of a nest were estimated to be the midpoint between the last observation of activity at the nest and the first observation with no activity. Dates of clutch completion and hatching were estimated by subtracting the length of the average incubation and nestling periods (calculated from detailed observations of nests at the Missile Base) from the estimated fledging date.

I examined some nests in natural sites using a 1-m fiberscope, reaching the cavities with a 10-m extension ladder (Rohwer 1988). The limited resolution and depth of field of the fiberscope did not allow precise counts of chicks or eggs in a nest, so I have accurate counts of eggs or chicks only for those nests I excavated. Cavities were excavated by carefully enlarging the existing entrance hole of the cavity with a saw. Cut-away pieces from excavations were replaced and secured with wire, thus maintaining the integrity of the cavity.

Some artificial cavities used as nest sites were nest boxes (both standard and Peterson box designs) or plastic Purple Martin (*Progne subis*) gourds (Carroll Industries, Van, Texas) I erected at the Missile Base. Nests in accessible artificial cavities were observed daily prior to egg-laying, during egg-laying, and for several days prior to hatching. Eggs were measured with dial calipers to the nearest 0.1 mm and weighed to the nearest 0.1 g with an electronic balance (Pocket Pro 150-B, Acculab, Newtown, Pennsylvania), generally on the day of laying.

At nests in accessible artificial cavities, I took measurements of chicks younger than 18 days old nearly every day. Mass was measured with the balance to the nearest 0.1 g. Straightened, flattened wing chord of the right wing was taken with dial calipers to the nearest 0.1 mm until the chord was about 15 mm long and thereafter with a ruler to the nearest 0.5 mm. Chicks within the same nest were identified by uniquely marking their wings or legs with a permanent felt-tip marker. These markings were superseded by color bands and numbered aluminum bands when the chicks were 7–14 days old. To avoid premature fledging, most chicks older than 17 days were simply counted without handling. Thus nestling periods are reported on a nest-wise basis (i.e., the period between the first chick hatching and the last chick fledging) instead of for individual chicks. Three late-season nests at the Missile Base received only enough visits to determine the number of chicks hatching and fledging. Permission to salvage and export several nests, eggs, and chicks was granted by the Bahamas Dept. of Agriculture.

Censusing or surveying highly mobile birds is difficult and my attempts to apply distance sampling techniques (Buckland et al. 1993) to survey Bahama Swallows along forest roads on Grand Bahama were unsuccessful. The distance data required for that method was impossible to collect, since swallows were often sighted while flying without any reference object nearby to which distance could be measured or even roughly estimated. Ultimately, I simply counted all swallows, whether foraging or perched, along separate survey routes in three areas of Grand Bahama on different days. Since I rarely observed other swallows on Grand Bahama during the breeding season, I assumed that all swallows I could not identify were Bahama Swallows. The three routes generally were covered on consecutive days. Weather on survey days typically was sunny and warm, with the few exceptions being slight overcast or cloudy conditions. The Eastern Lucaya route was 19 km of sparsely settled, relatively undeveloped subdivisions covered mostly with secondary forest and a dense network of roads. The second route covered 45 km in the Lucayan Estates subdivision, an area of secondary forest without any housing but with several farms and a dense road network. The East End route was 58 km long and used a logging road which ran down the center of much of the island. The eastern two-thirds of that route was relatively undisturbed secondary forest, and the remainder went through parts of Lucayan Estates. The routes were driven at a speed of 10–14 kph using either a moped (in May) or automobile (in June), beginning between 06:30 and 07:00 EST. I was both driver and observer for all Grand Bahama surveys.

In an earlier survey of Andros, Smith and Smith (1989) drove 96.4 km through the pine forest of that island at speeds under 30 kph on two days, 20–21 May 1988. An assistant and I performed one survey on Andros covering 76.0 km of the 1988 route (P. Smith, pers. comm.) following the 1988 protocol for the single day of our survey, 26 May 1995. For purposes of estimating the number of breeding pairs in all surveys, I assumed that groups of either one or two swallows represented one breeding pair and that groups of either three or four birds represented two breeding pairs. Juveniles identified as such were not counted.

RESULTS AND DISCUSSION

Nesting activity.—On 31 March, I noted the first exhibition of nesting behavior by Bahama Swallows since I had begun observations in mid-March. Swallows repeatedly flew up to and hovered in front of louvered access panels on the upper floors of a 12-story building near Freeport. I interpreted this activity as prospecting for nest sites and saw similar behavior at the same building on 2 April, when swallows approached the undersides of balconies and eaves. The first nesting behavior I observed at a natural nest site was on 2 April when two to four swallows flew around and approached a woodpecker hole in a snag. I observed a swallow taking nest material into that hole on 10 April. At this and other nests in natural sites, swallows were active at their nests only between about 07:00 and 11:00 during the nest-building stage, and attempts to find nests by observing adults at natural sites were fruitless later in the day.

Overall, I found 18 nests in natural nest sites: 10 nests seemed to be successful, five failed without fledging young, and three nests were still active when I left the island. To establish that nests in natural and artificial cavities did not differ in obvious ways, I examined nine of the 18 natural nests with a fiberscope. I found chicks in five of them, eggs in three of them, and neither eggs nor chicks in the last. In four nest sites that I excavated, I found incubated clutches of three eggs in each of two cavities, three chicks in another, and a partial nest in the last. What I saw of nests in natural cavities convinced me that they were similar to nests in artificial cavities with respect to clutch size and types of nest material used. I assume that most other aspects of breeding biology do not differ greatly between swallows nesting in natural and artificial sites.

Nest-site characteristics.—Although Bahama Swallows do use cavities in live trees (Smith and Smith 1989), all 18 nests I found in natural nest sites were in pine snags. All of those sites were abandoned woodpecker holes, except one which was in a large, cracked branch. The pine snags used for nesting had a mean diameter at breast height of 22.3 cm ($N = 18$, $SD = 4.26$, range: 17.0–28.3 cm). The mean height of the snags was 9.6 m ($N = 18$, $SD = 2.17$, range: 6.7–12.8 m), while the mean height of the cavities was 8.8 m ($N = 18$, $SD = 1.94$, range: 6.0–11.4 m). The

closest active nests that I found in natural cavities were about 150 m from each other.

All but two of 14 nests I found in artificial cavities were at the Missile Base. Types of artificial cavities used for nesting included housings of street lights (2 nests), a horizontal pipe (ca 5–6 cm diameter) (1 nest), a gap (less than 10 cm) between two sections of wall in the side of a building (1 nest), an electrical conduit box with the only access being a 42 mm diameter hole in the 15 cm × 13 cm floor of the box (1 nest), a Peterson-style nest box with a 38 mm diameter hole (1 nest), a standard nest box with a 38 mm diameter hole and 14 cm square floor (1 nest), an artificial nest gourd with a 55 mm diameter hole (1 nest), and rooftop ventilation units with rectangular access holes 95 mm wide by 28 mm high (6 nests in 5 units). The height of these artificial cavities ranged from 3.0 m for the Peterson box attached to a utility pole to 13.2 m for the pipe nest. The nest between two wall sections was an exception since it was at the top of the 12-story building at which I first saw nesting behavior. The two closest active nests were in ventilation units 8.8 m apart on top of the same roof.

Nest construction.—During observations of nest building at natural and artificial nest sites, I never saw both birds of a pair carrying nest material. I assumed that just one bird of each pair, which I took to be the female, did most, if not all, of the nest construction. The male often escorted the female while she was gathering nest material. I observed birds gathering nest material from the edges of paved and unpaved roads as well as from the middle of grassy areas that were recently mown. Caribbean pine needles, grass, and *Casuarina* spp. “needles” (actually fine, segmented twigs of this exotic tree) formed the bulk of the nests I examined in both artificial and natural nest sites. I observed one bird travel over 200 m from its nest site to collect material, but most trips for nest material by other birds were less than 100 m.

The period from when nest building began until clutches were initiated was 14–18 days in four nests built from scratch in artificial cavities. This period might be shorter for nests in natural sites since they contained less nest material than those in artificial sites. The masses of material from two nests collected from pine snags were quite small (9.0 g and 17.1 g) compared to the masses of material from four nests in artificial sites built completely in the season of the study (18.0 g, 41.6 g, 48.2 g, and 114.9 g). This difference may result from the generally larger volume of the artificial cavities. I collected eight nests, two from snags and six from artificial sites, after fledging or abandonment of the nests and deposited them with the Vertebrate Collection at Cornell Univ., Ithaca, New York.

Nest lining materials.—Nests were lined with a variety of materials,

both naturally occurring and artificial. Flakes of pine bark were common in nests, and I saw swallows pulling bark directly off trees on several occasions. Though not every nest contained bark, most contained 1–5 pieces of about 1–3 cm². Small downy feathers, seemingly originating from other passerines, were the other common natural lining material. Nests usually contained 1–5 such feathers, markedly fewer than the scores of waterfowl feathers often found in Tree Swallow nests (P. Allen, pers. obs.; Winkler 1993). The largest number of feathers I found in a nest was 15–25 flamingo feathers in a nest in a pine snag on the grounds of the Rand Nature Centre which maintained a small, captive flock of Greater Flamingos (*Phoenicopterus ruber*).

Other natural lining materials I found in nests included small dry leaves, pieces of skin shed from small lizards, yellow flower petals (found in only one nest), and a pale yellow butterfly wing (found in only one nest). In one incomplete nest in a snag less than 500 m from the seashore, I found several dried strands of turtle grass (*Thalassia testudinum*), a sea grass which commonly washes up on beaches. This may explain an observation of Bahama Swallows gathering mouthfuls of “seaweed” and flying towards the forest (Todd and Worthington 1911).

Artificial material in nest linings was most abundant at the Missile Base where litter was plentiful. Bits of shredded plastic wrap, small pieces of newspaper, facial tissue, and regular paper were common in nests there. These materials were presumably used because of their gross similarity to feathers. A few nests at the Missile Base also contained paint chips from paint peeling off buildings. If the birds actually pulled the paint chips off the buildings instead of picking them off the ground, then the actions required to do this would be similar to those used for collecting pine bark.

Eggs.—The eggs I examined from two nests in snags and 10 nests in artificial cavities were larger, on average, than Tree Swallow eggs in length, width, and mass (Table 1; masses of eggs from the two snags excluded because the eggs were not freshly laid). The mean clutch size was 3.0 eggs in these 12 nests and in an additional nest in an artificial cavity (Table 1). This is the same clutch size reported for a Caribbean congener, the Golden Swallow (*T. euchrysea*) (Turner and Rose 1989) but, not surprisingly, it is much smaller than for Tree Swallows (Table 1). Of these 11 nests in artificial cavities, two had clutches of two eggs, seven had three-egg clutches, and two had four-egg clutches. The two nests in natural cavities both had three-egg clutches. As with Tree Swallows (P. Allen, pers. obs.; Robertson et al. 1992), the color of freshly laid eggs was white, but translucent and slightly pinkish, changing to pure white after a few days of incubation. In all nests where laying was ob-

TABLE 1
COMPARISON OF BAHAMA SWALLOWS AND TREE SWALLOWS FOR SEVERAL ASPECTS OF
BREEDING BIOLOGY

	Bahama Swallow			Tree Swallow			<i>P</i> ^d
	N	$\bar{x} \pm SD$	Range	N	$\bar{x} \pm SD$	Range	
Egg length (mm) ^a	36	19.4 ± 0.72	17.2–20.6	2295	19.0 ± 0.90	16.0–22.8	*
Egg width (mm) ^a	36	13.9 ± 0.40	12.9–14.6	2292	13.6 ± 0.47	11.9–15.4	***
Egg mass (g) ^a	30	2.0 ± 0.19	1.6–2.3	835	1.8 ± 0.17	1.4–2.5	***
Clutch size (eggs) ^a	13	3.0 ± 0.58	2–4	847	5.4 ± 0.91	3–8	***
Incubation period (d) ^a	5	15.8 ± 1.10	15–17	235	14.5 ± 1.13	12–19	*
Hatching success ^b	30	86.7%	33.3–100	10,107	86.9%	—	—
Nestling success ^b	26	80.8%	0–100	21,130	83.1%	—	—
Nestling period (d) ^{a,c}	6	22.8 ± 1.21	22–25	554	20.6 ± 1.63	16–29	**

^a Tree Swallows in upstate New York (D. Winkler, unpubl. data).

^b Tree Swallows from several studies (Robertson et al. 1992).

^c Calculated for Tree Swallows on a nest-wise basis, just as with the Bahama Swallows.

^d Results from *t*-tests comparing means using equal or unequal variances as appropriate. * = $P \leq 0.05$, ** = $P \leq 0.01$, *** = $P \leq 0.001$.

served, eggs were laid one per day in the morning. I never observed Bahama Swallows copulating during this study.

Incubation.—Observations of five nests in artificial cavities yielded no consistent indication as to when incubation began. Even after the clutches were complete and incubation had presumably begun, eggs were often unattended when I checked the nests. This pattern may have resulted from often visiting nests in the early afternoon, generally the hottest part of the day. However, defining the incubation period as starting on the day the last egg was laid and ending on the day the first egg in the nest hatched, three nests had incubation periods of 15 days, and two nests had incubation periods of 17 days, giving a mean of 15.8 days (Table 1). This is over one day longer than the incubation period for Tree Swallows in upstate New York (Table 1). Though I did not often capture birds on the nest, there was no indication that males shared incubation responsibilities.

Hatching and survival.—Of the seven nests I visited daily during hatching, the eggs in three nests, two with two-egg clutches and one with a three-egg clutch, hatched in the same 24-hour period. The eggs in the four remaining nests, each containing three or four fertile eggs, hatched

over a period of 48 h. In those seven nests and in three late-season nests, 26 chicks (87%) hatched from 30 eggs (two eggs in one nest and one egg in a second nest were infertile; an additional egg was missing). Of the 26 chicks that hatched, 21 (81%) eventually fledged, giving an overall egg-to-fledgling success rate of 70%. The hatching and nestling success rates of these Bahama Swallows correspond closely with those of Tree Swallows from several studies (Table 1). The success rates for both these species are for birds nesting in artificial cavities, and success may be lower in natural cavities.

One three-day-old chick was found dead of unknown causes in its nest, while its nest mates remained in good health. One entire brood of three chicks was lost because they fell out of the ventilation unit that housed their nest. One other chick apparently was killed when the motor was activated in the ventilation unit that housed its nest. I salvaged three of these chicks and one of the infertile eggs, depositing them at Cornell. These are the only such specimens known for the Bahama Swallow (Smith and Smith 1989).

Nestling period and fledging.—In six successful nests that I monitored closely, the fledging period was 22 days for four nests, 23 days for the fifth nest, and 25 days for the remaining nest, giving a mean of 22.7 days (Table 1). This nestling period is two full days longer than that of Tree Swallows in upstate New York (Table 1). The siblings from three nests each containing two chicks fledged in the same 24-hour period. Siblings from another nest containing three chicks fledged over a 48-hour period. In two other nests with broods of three young, the fledging period was unknown because of imprecise counts of the young.

Chick development.—The rate of mass gain for Bahama Swallow chicks from seven nests was slower than that of Tree Swallows (Fig. 1), but the period during which chicks rapidly increased mass (days 1–12) was similar to that for Tree Swallow chicks. The mass of chicks from both species plateaus near their adult mass at about day 13 (Fig. 1). Growth rates, calculated by fitting a logistic curve to daily means of mass, show that Bahama Swallows ($K = 0.363$) grow more slowly than Tree Swallows ($K = 0.396$) using Tree Swallow data from McCarty (1995). Adult wing lengths of Bahama Swallows are about 4 mm shorter than those of Tree Swallows (Turner and Rose 1989), and the average length of Bahama Swallow wing chords was 2.3 mm shorter than, those of Tree Swallows for days 10–19 (Fig. 2).

In most respects, newly hatched Bahama Swallow chicks were similar to newly hatched Tree Swallow chicks (P. Allen, pers. obs.). The one exception was that all Bahama Swallow chicks were hatched with several down feathers (neossoptiles) already formed. Tree Swallows in New York

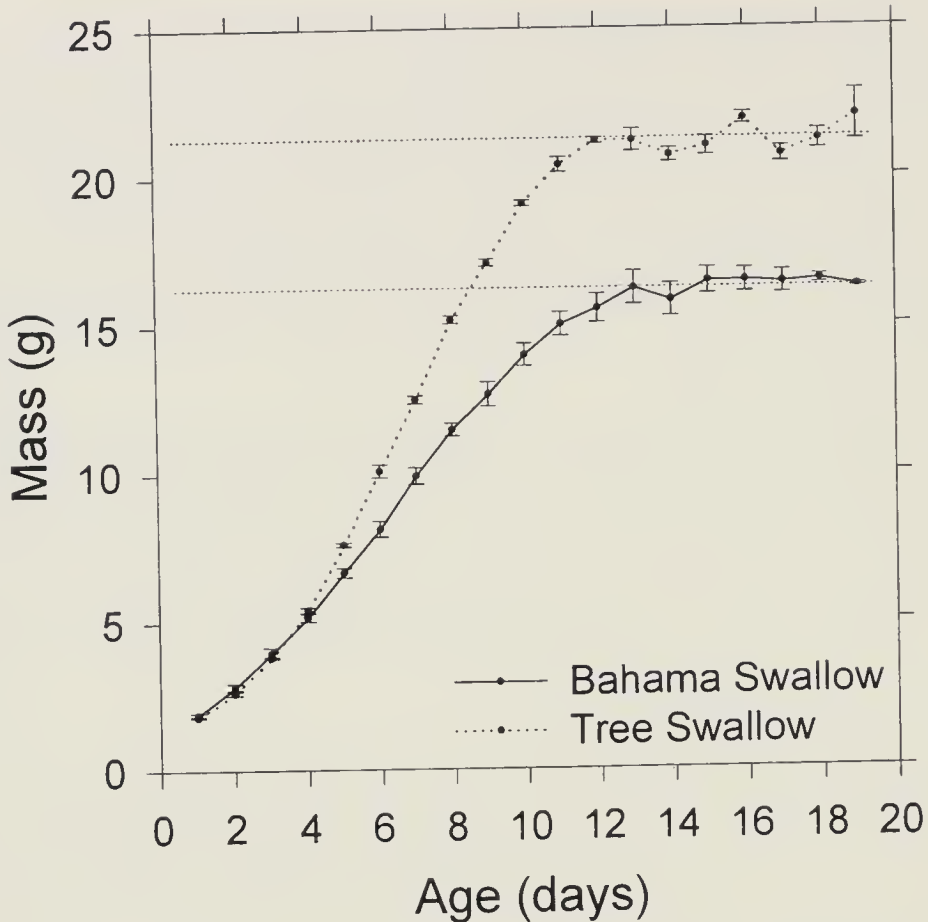


FIG. 1. Mass (means \pm 1 SE) of Tree Swallow (McCarty 1995) and Bahama Swallow chicks. Upper, dotted horizontal line shows adult mass of 21.3 g for Tree Swallows from McCarty (1995). Lower, dotted horizontal line shows mean mass of four breeding Bahama Swallow females captured at the Missile Base (16.3 g). This value corresponds with low end of mass range (16.3–19.5 g, mean 17.5 g) from museum specimens (Turner and Rose 1989).

often hatch completed naked and only occasionally hatch with one or more wispy down feathers (P. Allen, pers. obs.). In Bahama Swallows, dark feather tracts began showing underneath the skin on the wings by the second day. On the third day, tracts were visible on the head and back as well. Hair-like shafts of primaries as well as back and chest feathers began breaking through the skin on the fourth and fifth days. By the seventh day, the shafts of body feathers were less than 1 mm long. Primary and tail feathers began emerging from their shafts on about day nine or ten. By day ten, body feathers were emerged 1–2 mm from their shafts. The eyes of Bahama Swallow chicks began to open on their fifth day. Chicks' eyes were just small slits on days five or six with the slits widening until being fully rounded by the tenth day.

Parental care.—At least two adults, which I took to be the parents,

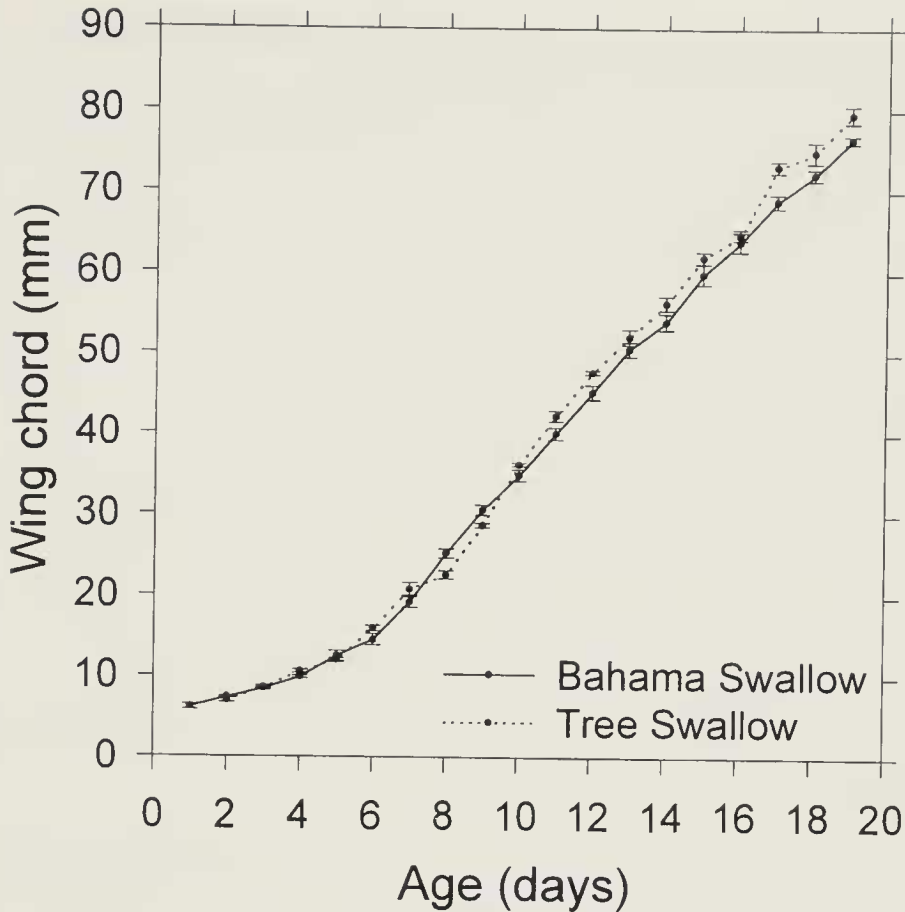


FIG. 2. Straightened, flattened wing chord (means \pm 1 SE) of Tree Swallow (McCarty 1995) and Bahama Swallow chicks.

fed young at most nests. At the Missile Base adults from neighboring nests assisted in defending nests against me during daily visits. In contrast to Tree Swallow nests, where it is common to find the entire nest well-covered in fecal matter after fledging (P. Allen, pers. obs.; Robertson et al. 1992), most Bahama Swallow nests in artificial cavities were clear of fecal material after chicks fledged. Either Bahama Swallow parents provided nest sanitation throughout the nestling phase or chicks were able to defecate out of the entrances to their cavities. However, I did not note much fouling of the area immediately below nests which would have indicated that the nestlings were responsible for sanitation.

Fledglings.—Observations of post-fledging chicks were difficult to obtain. In one case, I observed four fledglings (identified by their yellow gapes) perched in a tree with an adult feeding them. In another instance, I found four color-marked sibling fledglings in a group less than 500 m from their nest six days after the last chick had fledged from their nest.

Double broods.—Of the 12 nests at the Missile Base, at least one, and

possibly three, represented second broods after the successful fledging of a previous brood. I verified double brooding by a female banded at her first nest on 17 May while feeding chicks. She was captured again on 21 June on a second nest in a ventilation unit 10.7 m away from the first nest on the same rooftop. The first brood had fledged on 29 May and the second clutch was initiated on 18 June in a nest that I had found in April and identified as being an unused nest from a previous season. Some new nest material had been added to that nest, and rusty flakes of metal had been removed from the nest bowl prior to egg-laying. Four chicks fledged from the first brood, and two chicks fledged from the second.

Another possible double-brood attempt was a clutch of three eggs I found on 16 June in the same nest from which three chicks had fledged on 4 June. The second brood in that nest produced two fledglings. Another possible case of double-brooding was a clutch initiated on 14 June in a nest box within 25 m of an inaccessible nest that was active until sometime during the first week of June. The initiation of this late clutch falls within days of the initiations for the two other double-brood nests, after a period of more than four weeks without a known clutch initiation at the Missile Base.

I made a special effort to look for renewed nesting activity at natural sites in mid-June but was unable to confirm any other possible second-brood nests. Finding such nests might be especially difficult if nests used earlier in the season were simply reused without more nest building. The last search for new nests at the Missile Base was on 26 June, so I do not know if there were more late-season nests initiated there after that date.

Overall phenology.—The mean date of clutch completion for nine nests in snags and eight nests in artificial cavities (which excludes the three late-season nests) was 5 May (SD 6.96, range: 20 April–15 May). The average date of hatching for those clutches was 20 May (SD 6.98, range: 5 May–28 May), and the mean fledging date was 11 June (N = 16, SD 7.30, range: 27 May–22 June). For the two late-season nests in which I observed egg-laying, the average date of clutch completion was 18 June. The mean estimated dates of hatching and fledging for those two broods were 4 July and 26 July, respectively.

Interspecific competition.—Bahama Swallows nesting in natural nest sites had numerous interspecific agonistic interactions with four other cavity-nesting bird species. Two were native species, the Hairy Woodpecker (*Picoides villosus*) and La Sagra's Flycatcher (*Myiarchus sagrae*). The other two, House Sparrow (*Passer domesticus*) and European Starling (*Sturnus vulgaris*), were exotic. In two interactions with woodpeckers, swallows harassed woodpeckers which were in possession of nest sites, but in both cases the woodpeckers remained in control of the cavities.

However, I did find two cases of swallows nesting quite close to woodpeckers. In one instance, active swallow and woodpecker nests were 30 m apart, and in another, the nests were 75–100 m apart. I observed a swallow being displaced from the rim of a nest-hole in a snag by a flycatcher bringing either food or nest material into the cavity. In two other cases, flycatchers perching at former swallow nest sites were displaced by swallows, even though the swallow chicks had already fledged. I found one instance of flycatchers and swallows nesting within 100 m of each other. In a case that is difficult to interpret, I excavated a nest site several weeks after I had seen swallows entering the cavity, and found it filled with typical House Sparrow nest material but with four rotten flycatcher eggs at the bottom. I observed no direct interactions between House Sparrows and Bahama Swallows. However, one cavity in which swallows were nest building was later usurped by sparrows which successfully raised a brood of young there. In another instance, I found a pair of sparrows inspecting a cavity in which there had been an active swallow nest with eggs about two weeks earlier. However, I do not have observations for the intervening period to give any hints as to whether the swallows had abandoned because of the sparrows. The Missile Base had a healthy population of breeding House Sparrows which seemed to exclude swallows from nesting in sites they might typically choose in the absence of sparrows. The sparrows had a monopoly on nest sites under the eaves of the roofs, while the swallows nested, for the most part, in sites that gave no means of clinging to the entrance hole or perching before entering the cavity. Such sites were probably difficult or impossible for sparrows to access. I observed very few interactions between starlings and swallows, but I did find one active starling nest within 75 m of a swallow nest.

Although the exotic cavity nesters have the potential to impact greatly the Bahama Swallow through competition for nest sites, I found these species mainly within about one kilometer of human structures or other disturbance. I never observed either species in undisturbed secondary forest, but House Sparrows were at farms in the middle of the secondary forest. As human development and disturbance encroach on the forest, it is inevitable that the local ranges of these exotics will spread.

Previous surveys and density estimates.—Emlen (1977) estimated a Bahama Swallow density of $11.0 \text{ birds-km}^{-2}$ in pine forest during the breeding season by surveying a total of 21.5 km of transects using the coefficient of detectability methodology (Emlen 1971). Using Henry's (1974) estimate of the total pineland area extant at that time (1782 km^2), Emlen's density figure results in a population estimate of just under 20,000 birds in the entire species' breeding range. Caution should be used

before considering this quick extrapolation as a true reflection of the Bahama Swallow population during that study, since the survey transects seemed to have been restricted to prime breeding habitat (Emlen 1977). Also, Emlen (1977) was mainly concerned with making relative, interspecific comparisons among species and did not attempt to make absolute estimates of population sizes.

Smith and Smith (1989) is the only other source of quantitative data for the Bahama Swallow. From a simple road survey in 1988, they estimated the density of breeding Bahama Swallows at 2.6 birds-km⁻² (Smith and Smith 1989). Using this density estimate and Henry's (1974) estimate of pine forest area, the total breeding population of the Bahama Swallow would have been about 4800 birds. Smith and Smith (1989) conceded the imprecision of the estimate but felt the result was of the correct magnitude, between 1000 and 10,000 living Bahama Swallows. This estimate is quite different from one derived from Emlen's data, but it is debatable whether the difference in the two results reflects an actual decrease in the Bahama Swallow population, at least of the magnitude indicated. A direct comparison between the two results can be misleading, since the methods used were different.

Grand Bahama surveys.—In the surveys I performed, the results from each of the three individual routes were somewhat irregular (Fig. 3; Eastern Lucaya range: 0.10–0.56 pairs-km⁻¹; Lucayan Estates range: 0.11–0.30 pairs-km⁻¹; East End range: 0.12–0.27 pairs-km⁻¹). A weighted average of the sightings from the three routes showed a pattern of increasing frequency of sightings, from 0.17 pairs-km⁻¹ to 0.25 pairs-km⁻¹, during the period between the average dates of hatching and fledging (Fig. 4). This is consistent with adult swallows spending more time foraging in response to an increased demand for food as their chicks develop. Estimating breeding density from these results would be misleading because of the assumptions required to do so (e.g., that only birds breeding within a certain distance of the road were sighted) and because of bias introduced by what seemed to be an affinity to the road by the birds. Instead, the survey results should be considered indices to the population size.

Andros survey.—The 1995 Andros survey served to make a direct comparison between contemporary survey results and those of Smith and Smith (1989) without complications in interpretation arising from different protocols or routes. In 1988, Smith and Smith (1989) observed 0.28 pairs-km⁻¹. In 1995, we saw eight single swallows and eight two-somes while covering just 70% of the 1988 route, giving a sighting rate of 0.21 pairs-km⁻¹. Though the 1995 result represents a 25% decrease from the 1988 survey, the limited nature of the Andros surveys precludes the conclusion that the decrease reflects a population decline. However, since the

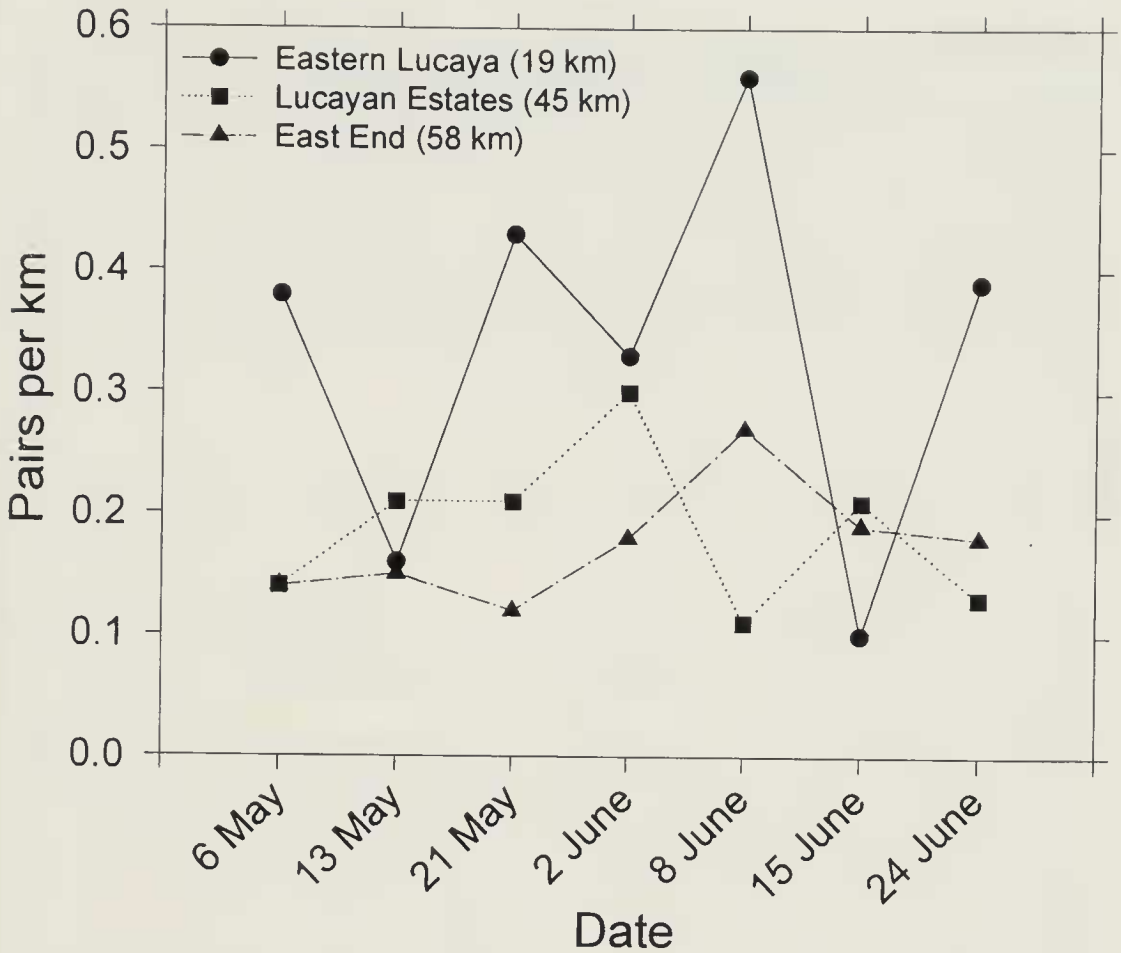


FIG. 3. Bahama Swallow pairs- km^{-1} from each of three survey routes sampled on three roughly consecutive days. Date is the day that the second route was sampled. The large variance of sightings on the Eastern Lucaya route is probably due to its shorter length.

result of the 1995 Andros survey roughly corresponds to the results of surveys on Grand Bahama near the same time (0.20 pairs- km^{-1} for 21 May and 0.25 pairs- km^{-1} for 2 June), it seems likely that the 1995 Andros results may be a reasonable index of the Andros population.

Conclusion.—Like many other species, the greatest threat the Bahama Swallow faces probably is habitat destruction. The most likely cause of major habitat alteration loss in the Bahamas will be logging, especially since much of the secondary forest is now becoming mature after the last spate of harvesting. However, another source of major habitat loss will be from housing development, particularly when the residential retirement and resort communities planned for Grand Bahama are more fully implemented. According to promotional brochures, these subdivisions are to house over 500,000 people and cover about 170 km^2 (P. Allen, unpubl. data), most of which is currently forested. This area was not included in

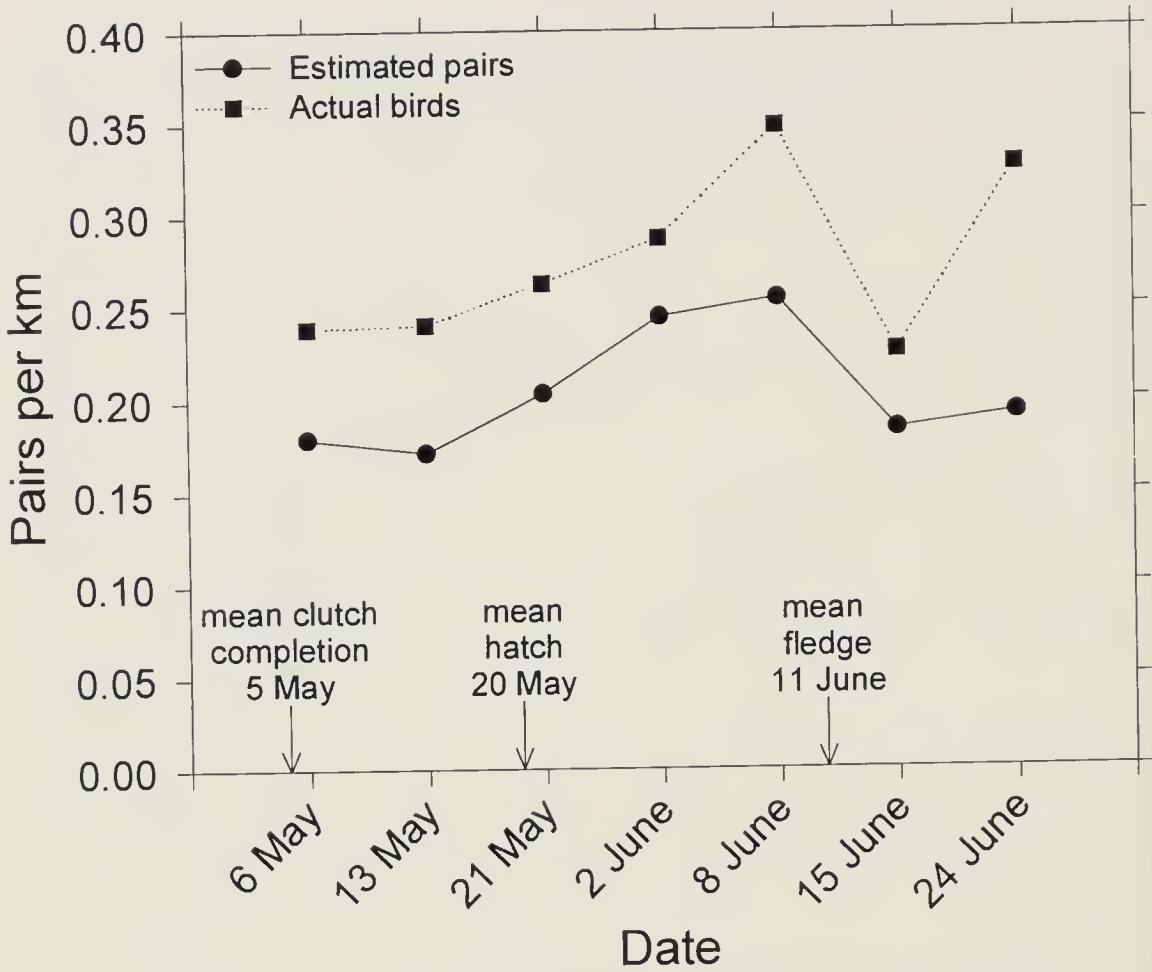


FIG. 4. Survey results combining the three routes of each survey using actual number of birds sighted (dashed line) or estimated number of pairs sighted (solid line). Date is the day that the second route was sampled.

the pine forest inventory by Allan (1986), but its development will effectively eliminate about 8% of the breeding habitat currently available to Bahama Swallows. Hurricanes pose another threat to Bahama Swallow habitat since they can demolish large portions of the forest on individual islands and have done so before in the Bahamas. However, if habitat loss from all sources can be minimized, and possibly mitigated through conservation measures such as nest box and snag management programs, the Bahama Swallow does not seem likely to become endangered. But, given the limited area of pine forest and the vulnerability of that habitat to human alteration, it seems unlikely that the conservation status of the species could ever be upgraded from its current near-threatened status.

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LITERATURE CITED

- ALLAN, T. G. 1986. Management plan for the pine forests of the Bahamas. UTF/BHA/003/BHA Consultancy Report No. 2. Food and Agriculture Organization of the United Nations.
- AMERICAN ORNITHOLOGISTS' UNION. 1983. Check-list of North American birds. 6th ed. A.O.U., Washington, D.C.
- BUCKLAND, S. T., D. R. ANDERSON, K. P. BURNHAM, AND J. L. LAAKE. 1993. Distance sampling: estimating abundance of biological populations. Chapman and Hall, London, England.
- COLLAR, N. J., L. P. GONZAGA, N. KRABBE, A. MADRONO NIETO, L. G. NARANJO, T. A. PARKER III, AND D. C. WEGE. 1992. Threatened birds of the Americas. The ICBP/IUCN red data book. Smithsonian Institution Press, Washington, D.C.
- EMLEN, J. T. 1971. Population densities of birds derived from transect counts. *Auk* 88:323-342.
- . 1977. Land bird communities of Grand Bahama Island: the structure and dynamics of an avifauna. Ornithological Monograph No. 24. Allen Press Inc., Lawrence, Kansas.
- HENRY, P. W. T. 1974. The pine forests of the Bahamas. British Foreign and Commonwealth Office Land Resource Study No. 16.
- MCCARTY, J. P. 1995. Effects of short-term changes in environmental conditions on the foraging ecology and reproductive success of Tree Swallows, *Tachycineta bicolor*. Ph.D. diss. Cornell Univ., Ithaca, New York.
- ROBERTSON, R. J., B. J. STUTCHBURY, AND R. R. COHEN. 1992. Tree Swallow. (*Tachycineta bicolor*) In The birds of North America, No. 11 (A. Poole, P. Stettenheim, and F. Gill, eds.). The Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, D.C.
- ROHWER, S. 1988. Guyed extension ladder for access to high nests. *J. Field Ornithol.* 59: 262-265.
- SMITH, P. W. AND S. A. SMITH. 1989. The Bahama Swallow *Tachycineta cyaneoviridis*; a summary. *Bulletin of the British Ornithologists' Club* 109:170-180.
- SWENSON, J. 1986. Bahamas forest inventory. UTF/BHA/003/BHA consultancy report No. 7. Food and Agriculture Organization of the United Nations.
- TODD, W. E. AND W. W. WORTHINGTON. 1911. A contribution to the ornithology of the Bahama Islands. *Ann. Carnegie Mus.* 7:388-464.
- TURNER, A. AND C. ROSE. 1989. A handbook to the swallows and martins of the world. Christopher Helm, London, England.
- WINKLER, D. W. 1993. Use and importance of feathers as nest lining in Tree Swallows (*Tachycineta bicolor*). *Auk* 110:29-36.